

WHAT IS CLAIMED IS:

1. An optical transmission system which transports information over fiber-optic transmission lines of upstream and downstream links, comprising:  
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(a) an end station comprising:

monitoring signal transmission means for transmitting over the upstream link a monitoring request signal including a monitoring command signal with a first optical wavelength and a response carrier wave with a second optical wavelength which is different from the first optical wavelength, the monitoring command signal requesting a specified repeater to provide information about operating status thereof, the response carrier wave being a carrier wave for the specified repeater to return the requested information as a monitoring response signal,  
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15 and

operating status receiving means for receiving the monitoring response signal and identifying the operating status of the specified repeater from the received monitoring response signal; and  
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(b) a repeater comprising:

an upstream optical coupler, attached to the upstream link, which has a first port for splitting off a part of upstream transmission signals including the monitoring request signal sent from said end station and a second port for taking out an optical signal that enters  
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the first port,

an upstream wavelength selection means, coupled to the first port of said upstream optical coupler, for selectively passing the first optical wavelength and  
5 reflecting back the second optical wavelength, thereby extracting the monitoring command signal from the monitoring request signal received through said upstream optical coupler while reflecting the response carrier wave back to the first port,

10 monitoring control means, responsive to the monitoring command signal supplied from said upstream wavelength selection means, for collecting information about operating status of said repeater, and encoding the collected information into a response message signal,

15 excitation means for supplying a pump beam into the fiber-optic transmission line of the upstream link to perform optical amplification using the fiber-optic transmission line as an amplifying medium,

modulation control means, coupled to said  
20 excitation means, for modulating the pump beam with the response message signal, whereby the response message signal is superimposed on the response carrier wave propagating on the upstream link and the resulting monitoring response signal reaches said upstream optical  
25 coupler, and

a downstream optical coupler, attached to the downstream link, which has a port to accept the monitoring

response signal from the second port of said upstream optical coupler and direct the monitoring response signal into the downstream link for delivery to said operating status receiving means in said end station.

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2. The optical transmission system according to claim 1, wherein said upstream wavelength selection means is a fiber grating device which selectively reflects back the second optical wavelength.

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3. The optical transmission system according to claim 1, wherein said modulation control means performs amplitude modulation, thereby causing the response carrier wave to be amplitude-modulated.

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4. The optical transmission system according to claim 1, wherein said excitation means comprises a WDM coupler which supplies the modulated pump beam into the fiber-optic transmission line to perform either of forward pumping, backward pumping, and two-way pumping.

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5. The optical transmission system according to claim 4, wherein said repeater further comprises an optical isolator disposed between said upstream optical coupler and WDM coupler.

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6. The optical transmission system according

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to claim 1, wherein said excitation means further performs erbium-doped fiber amplification.

7. The optical transmission system according  
5 to claim 1, wherein:

said monitoring signal transmission means stops sending the response carrier wave when incoming optical transmission signals are available on the downstream link; and

10 said excitation means further supplies the modulated pump beam into the fiber-optic transmission line of the downstream link, whereby the response message signal is superimposed on the incoming optical transmission signals on the downstream link.

15 8. The optical transmission system according to claim 1, wherein said modulation control means is configured with a variable modulation factor, including a maximum modulation factor to be applied when in out-of-  
20 service state.

9. The optical transmission system according to claim 1, which comprises a plurality of said repeaters, wherein:

25 said each repeater further comprises a downstream wavelength selection means coupled to said downstream optical coupler; and

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      said upstream and downstream wavelength selection means in said plurality of repeaters have the same reflecting wavelength.

5           10.      The optical transmission system according to claim 1, which comprises a plurality of said repeaters, wherein:

10         said each repeater further comprises a downstream wavelength selection means coupled to said downstream optical coupler; and

      said upstream and downstream wavelength selection means in said plurality of repeaters have different reflecting wavelengths from each other.

15         11.      The optical transmission system according to claim 1, which comprises a plurality of said repeaters, wherein:

20         said repeater further comprises a downstream wavelength selection means coupled to said downstream optical coupler; and

      said downstream wavelength selection means in said plurality of repeaters have a common reflecting wavelength that is different from what said upstream wavelength selection means reflect equally.

25         12.      The optical transmission system according to claim 1, wherein:

the information signals are wavelength-division multiplexed signals having wavelengths of  $\lambda_1$  to  $\lambda_n$  (n: integer); and

5 the monitoring signal transmission means assigns either of the shortest wavelength  $\lambda_1$ , the longest wavelength  $\lambda_n$ , and an intermediary wavelength between two consecutive wavelengths  $\lambda_m$  and  $\lambda_{m+1}$  ( $m < n$ ) to the second optical wavelength.

10 13. An optical transmission system which transports information over fiber-optic transmission lines of upstream and downstream links, comprising:

(a) an end station comprising:

15 monitoring signal transmission means for transmitting over the upstream link a monitoring request signal including a monitoring command signal with a first optical wavelength and a response carrier wave with a second optical wavelength which is different from the first optical wavelength, the monitoring command signal requesting a specified repeater to provide information about operating status thereof, the response carrier wave being a carrier wave for the specified repeater to return the requested information as a monitoring response signal, and

25 operating status receiving means for receiving the monitoring response signal and identifying the operating status of the specified repeater from the received

monitoring response signal; and

(b) a repeater comprising:

an upstream optical coupler, attached to the upstream link, which has a first port for splitting off a part of upstream transmission signals including the monitoring request signal sent from said end station and a second port for taking out an optical signal that enters the first port,

an upstream wavelength selection means, coupled to the first port of said upstream optical coupler, for selectively passing the first optical wavelength and reflecting back the second optical wavelength, thereby extracting the monitoring command signal from the monitoring request signal received through said upstream optical coupler while reflecting the response carrier wave back to the first port,

monitoring control means, responsive to the monitoring command signal supplied from said upstream wavelength selection means, for collecting information about operating status of said repeater, and encoding the collected information into a response message signal,

monitoring response signal generating means, coupled to said monitoring control means, for producing a monitoring response signal by using an optical modulator to modulate the response carrier wave with the response message signal, the optical modulator using either of variable optical attenuation and tuned filtering

techniques, and

a downstream optical coupler, attached to the downstream link, which has a port to accept the monitoring response signal from the second port of said upstream 5 optical coupler and direct the monitoring response signal into the downstream link for delivery to said operating status receiving means in said end station.

14. The optical transmission system according 10 to claim 13, wherein said optical modulator is disposed between the second port of said upstream optical coupler and said downstream optical coupler.

15. An end station in an optical transmission 15 system which transports signals over fiber-optic transmission lines of upstream and downstream links, comprising:

monitoring signal transmission means for transmitting over the upstream link a monitoring request signal including a monitoring command signal with a first optical wavelength and a response carrier wave with a second optical wavelength which is different from the first optical wavelength, the monitoring command signal requesting a specified repeater to provide information 20 about operating status thereof, the response carrier wave being a carrier wave for the specified repeater to return the requested information as a monitoring response signal; 25

and

operating status receiving means for receiving the monitoring response signal and identifying the operating status of the specified repeater from the received 5 monitoring response signal.

16. A repeater in an optical transmission system which transports information over fiber-optic transmission lines of upstream and downstream links, 10 comprising:

an upstream optical coupler, attached to the upstream link, which has a first port for splitting off a part of upstream transmission signals and a second port for taking out an optical signal that enters the first 15 port, the split part of the upstream transmission signals including a monitoring request signal including a monitoring command signal with a first optical wavelength and a response carrier wave with a second optical wavelength which is different from the first optical wavelength, the monitoring command signal requesting a 20 specified repeater to provide information about operating status thereof, the response carrier wave being a carrier wave for the specified repeater to return the requested information as a monitoring response signal;

25 an upstream wavelength selection means, coupled to the first port of said upstream optical coupler, for selectively passing the first optical wavelength and

reflecting back the second optical wavelength, thereby extracting the monitoring command signal from the monitoring request signal received through said upstream optical coupler while reflecting the response carrier wave

5 back to the first port;

monitoring control means, responsive to the monitoring command signal supplied from said upstream wavelength selection means, for collecting information about operating status of said repeater, and encoding the 10 collected information into a response message signal;

excitation means for supplying a pump beam into the fiber-optic transmission line of the upstream link to perform optical amplification using the fiber-optic transmission line as an amplifying medium;

15 modulation control means, coupled to said excitation means, for modulating the pump beam with the response message signal, whereby the response message signal is superimposed on the response carrier wave propagating on the upstream link and the resulting 20 monitoring response signal reaches said upstream optical coupler; and

a downstream optical coupler, attached to the downstream link, which has a port to accept the monitoring response signal from the second port of said upstream optical coupler and direct the monitoring response signal 25 into the downstream link.

17. An optical transmission system which transports information over fiber-optic transmission lines of upstream and downstream links, comprising:

(a) an end station comprising:

5 monitoring signal transmission means for transmitting over the upstream link a monitoring request signal including a monitoring command signal with a predetermined optical wavelength and a response carrier wave with the same predetermined optical wavelength, the  
10 monitoring command signal requesting a specified repeater to provide information about operating status thereof, the response carrier wave being a carrier wave for the specified repeater to return the requested information as a monitoring response signal, and

15 operating status receiving means for receiving the monitoring response signal and identifying the operating status of the specified repeater from the received monitoring response signal; and

(b) a repeater comprising:

20 a first upstream optical coupler, attached to the upstream link, which has a first port for splitting off a part of upstream transmission signals, including the monitoring request signal, and a second port for taking out an optical signal that enters the first port,

25 an upstream wavelength reflection means, coupled to the first port of said first upstream optical coupler, for selectively reflecting back the predetermined optical

wavelength,

a second upstream optical coupler, attached to the upstream link, for receiving the monitoring command signal, monitoring control means, responsive to the monitoring command signal received by said second upstream optical coupler, for collecting information about operating status of said repeater, and encoding the collected information into a response message signal,

excitation means for supplying a pump beam into the fiber-optic transmission line of the upstream link to perform optical amplification using the fiber-optic transmission line as an amplifying medium,

modulation control means, coupled to said excitation means, for modulating the pump beam with the response message signal, whereby the response message signal is superimposed on the response carrier wave propagating on the upstream link and the resulting monitoring response signal reaches said first upstream optical coupler, and

a downstream optical coupler, attached to the downstream link, which has a port to accept the monitoring response signal from the second port of said first upstream optical coupler and direct the monitoring response signal into the downstream link for delivery to said operating status receiving means in said end station.

18. An end station in an optical transmission

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system which transports signals over fiber-optic transmission lines of upstream and downstream links, comprising:

monitoring signal transmission means for  
5 transmitting over the upstream link a monitoring request signal including a monitoring command signal with a predetermined optical wavelength and a response carrier wave with the same predetermined optical wavelength, the monitoring command signal requesting a specified repeater  
10 to provide information about operating status thereof, the response carrier wave being a carrier wave for the specified repeater to return the requested information as a monitoring response signal; and

operating status receiving means for receiving the  
15 monitoring response signal and identifying the operating status of the specified repeater from the received monitoring response signal.

19. A repeater in an optical transmission system which transports information over fiber-optic transmission lines of upstream and downstream links, comprising:

a first upstream optical coupler, attached to the upstream link, which has a first port for splitting off a  
25 part of upstream transmission signals and a second port for taking out an optical signal that enters the first port, the split part of the upstream transmission signals

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including a monitoring request signal including a monitoring command signal with a predetermined optical wavelength and a response carrier wave with the same predetermined optical wavelength, the monitoring command  
5 signal requesting said repeater to provide information about operating status thereof, the response carrier wave being a carrier wave for the specified repeater to return the requested information as a monitoring response signal;

an upstream wavelength reflection means, coupled  
10 to the first port of said first upstream optical coupler, for selectively reflecting back the predetermined optical wavelength;

a second upstream optical coupler, attached to the upstream link, for receiving the monitoring command  
15 signal;

monitoring control means, responsive to the monitoring command signal received by said second upstream optical coupler, for collecting information about operating status of said repeater, and encoding the  
20 collected information into a response message signal;

excitation means for supplying a pump beam into the fiber-optic transmission line of the upstream link to perform optical amplification using the fiber-optic transmission line as an amplifying medium;

25 modulation control means, coupled to said excitation means, for modulating the pump beam with the response message signal, whereby the response message

signal is superimposed on the response carrier wave propagating on the upstream link and the resulting monitoring response signal reaches said first upstream optical coupler; and

5           a downstream optical coupler, attached to the downstream link, which has a port to accept the monitoring response signal from the second port of said first upstream optical coupler and direct the monitoring response signal into the downstream link.